SNOWMOBILES AND OFF ROAD VEHICLES IN MONTANA

A Review of Literature

by

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CONTENTS

SUMMARY RECOMMENDATIONS

1. Environmental impact studies of snowmobiles and off-road vehicles should be part of state and county land use plans.

2. Initiate a survey of field personnel experiences to record known environmental impacts.

3. Encourage research of special problems related to the environmental impacts of snowmobiles and off-road vehicle use.

4. Immediately, initiate a multi-stage user survey including:

   (a) A survey of registered snowmobile owners.
   (b) An on-site survey of users while engaged in the activity.
   (c) A household survey of motorized and non-motorized users.
   (d) An origin and destination study of off-road vehicle users in route.

5. Develop a system of trails with standard signing and minimum basic facilities on public and private lands.

6. Inventory and analyze existing off road vehicle trails and record opportunities for future developments.

7. Make trail maps and informational brochures available to the public.

8. Develop a planning program to provide umbrella guidance to off-road vehicle planning and management.

9. Prepare coordinated enforcement guidelines and conduct training sessions for state, county and federal enforcement personnel.

10. Rely on spatial and temporal zoning as a basic tool to restrict use on areas of adverse environmental impact and on areas where serious conflicts occur with other recreation user groups.

11. Develop uniform regulations, consistent to the degree possible, with other state and federal land managing agencies.

12. Review and update existing legislation to reflect the experiences of other states and federal agencies with off-road vehicle use and management.

INTRODUCTION

This study was sponsored by the Recreation and Parks Division of the Montana Department of Fish and Game. It is intended to provide background information for more in depth studies on off-road vehicular use in Montana. The study was initiated by a planning project funded by the Bureau of Outdoor Recreation and will serve as an element of the Montana Outdoor Recreation Plan.

This report is a review and analysis of available literature and research in the field of snowmobiles and off-road vehicles. As directed by the Department of Fish and Game, special emphasis has been placed on snowmobiles and on studies completed in or pertinent to the northern Rocky Mountains. Rather than an exhaustive review of all literature in the field, this study concentrates on those materials most relevant to the management of off-road vehicular use. Specifically, the literature on environmental impacts, user characteristics and preferences, and conflicts with other recreation uses was reviewed and analyzed.

This initial effort is intended to pin-point the most critical problems arising from off-road vehicle use. It also suggests preliminary policy guidelines, not only in the control and management of off-road vehicles, but also in the provision of opportunities for their compatible use. Lastly, this report makes recommendations on studies that should be initiated to provide additional information for the planning and management of snowmobile and off-road vehicle use.

The author acknowledges the assistance and cooperation of many agencies, organizations and individuals, too numerous to specifically mention, that have provided study reports and background information for this analysis. In particular, I wish to acknowledge the excellent review of literature by Norma Jean Lodico, sent to me by the Bureau of Outdoor Recreation. Her report contributed much information for the chapter on environmental impacts. I also want to thank Al Thompson and his staff for their helpful review and critique of preliminary draft materials.

ENVIRONMENTAL IMPACTS

SNOWMOBILES

Effects on Vegetation: Whittaker (93,95) conducted a pilot study in Maine to determine if the compaction from snowmobiles caused diminished yields of forage crops. Test plots were traversed a varying number of times with snowmobiles with the most-run plot (300 trips) yielding 10 tons less per acre than the least-run plot (100 trips) and 12.7 tons less per acre than the control plot. Although variations in yield were not statistically conclusive, the results of this testing suggest that snowmobile compaction may cause diminished yields from clover, timothy and alfalfa fields (94).

In a study near Ottawa, Canada, Neumann and Merriam reported that snowmobile damage to hardwood saplings and planted pines was significant (61). The study indicated that 78 percent of the saplings on a woodland trail were damaged by a single passage of a snowmobile. On trails which received heavy use, all vegetation above the compacted snow surface was mechanically eradicated.

Wanek (85, 86, 87) studied soil temperature, soil microbe activity, and plant damage in hardwood forests and in Norway Pine and White Spruce plantations on the Chippewa National Forest in Minnesota. He found that small pine trees were more resilient and less prone to trunk breakage than young white spruce and that larger trees and shrubs, not imbedded in snow, were heavily damaged. Damage was also found to increase significantly with increased snowmobile traffic. The study further showed that lowering soil temperatures through snow compaction could affect the survival of many species by killing underground perennating structures. The lag in the spring soil warm-up could retard the life cycle of ephemerals, jeopardizing their survival. Nutrient cycles and humus formation may also be affected by the curtailment of soil microbe activities (86).

Boggs (77) pointed out that snowmobiles operate at a time when the effects on the environment are minimal. In Idaho, wheat farmers reported no instances where wheat was killed as a result of snowmobile operation, although compaction from heavy traffic might result in a higher incidence of snow mold.

In a case study of off-road vehicles in California, Miller (54) noted that the environmental problems caused by snowmobiles had not yet been severe enough to warrant closures and that the effects on soil and watersheds is thus far almost nonexistent.

In a Wisconsin study, Pendleton, et al, (64, 65) reported heavy losses of alfalfa under light and irregular snow cover, 30 percent reduction in yields under moderate snows, and no perceptible losses under heavy snow cover. Losses in alfalfa yield did not appear to be caused by soil compaction. They found that the amount of traffic had minor effect on yield as compared to snow depth.

Effects on Wildlife: Using radio telemetry to investigate reactions of wildlife to snowmobiles, Wanek (85, 87) reported that deer appear to lose their natural wariness in heavily used areas. He also observed that when deer experience a snowmobile invasion, where the machines rarely travel, they react violently. This might be detrimental to their survival due to the more rapid expenditure of energy, upsetting the delicate balance between stored body fat and harsh winter environment.

Pruitt (67) explained that at the base of a slowly developed snow cover, temperatures range slightly below freezing regardless of the surface temperature. He stated that the subnivean space and the pukak layer directly below is of great importance to the survival of small mammals. From his analyses of density and temperature changes, Pruitt concluded snowmobiles completely destroy the pukak layer, By comparison, an equivalent of fifty people on snowmobiles, because of the way in which pressure is generated, would not completely destroy this layer.

Jarvinen and Schmid (41) further documented the importance of snow cover to the survival of small mammals. Their capture data indicated no emigration from packed to unpacked plots and suggested very high (100%) mortality rates after snowmobile compaction. Both compaction and temperature stress were cited as contributing factors. The possibility was also raised that carbon dioxide accumulations in packed snow could make the air toxic to mammals.

Schmidt (77) also reported that mechanical compaction of snowfields by snowmobiles alters the subnivean microclimate and promots densification of snow. The study showed that snow roosting by birds was prevented and the movement of small mammals was curtailed.

Neumann and Merriam (61) found that snowshoe hare and red fox mobility and distribution were affected by snowmobile use. Activity data for snowshoe hares indicate that browsing was significantly lower within 76 meters of a repeatedly used snowmobile trail. However, red fox activity was much greater close to snowmobile trails, apparently because of increased mobility.

Baldwin (5) cited a number of reports of wildlife harassment and running down game. He stated that harassment was causing an unusual number of abortions in wild animals. He also mentioned the possibility of over fishing lakes previously inaccessible in winter.

Doan (20) summarized the adverse effects on wildlife resulting from snowmobile activities in Manitoba. He noted that snowmobile hunters have a great potential for reducing the number of big game animals. Doan cited complaints that snowmobiles flush wintering animals and birds from limited and essential cover thus contributing to their overexposure.

In the 1971 Senate Hearing, Pickelner (77) mentioned many reports of wildlife harassment, ranging fro- the practice of running over coyotes, foxes and other unpopular animals, to unintentional frightening of wildlife by curious onlookers. He stated that the pressure on wildlife, particularly where snowmobiles intrude into their wintering grounds, is significant. Stevens (77) also testified that some snowmobile drivers played a game called "spooking" in which animals are chased until they drop and then often die of exhaustion or pneumonia.

In the same hearing, Nelson (77) said that snow surveyors and conservation officers have been using various types of noisy snow machines for thirty years and the game has not been disturbed or excited by noise alone. He said that it is only when vehicles speed toward the animals that they become wildly excited. If, however, a vehicle is properly and considerately operated, it is possible to even feed game from trucks or other vehicles without frightening the animals. They soon learn that the operators mean no harm and they become very tame.

Wettersten (92) reported that Minnesota conservation officers had to go out on a number of occasions and pick up moose and deer purposefully run to death by snowmobilers. He also said that during a survey of deer yards, a number of animals was found that had died during periods of winter stress--they died from being run by snowmobiles rather than starvation.

Olsen (62) reported that in Alberta, Canada farmers have been complaining about the proliferation of grain-eating gophers and mice after running down and killing coyotes with snowmobiles. Meanwhile, the rodents that make up the bulk of the coyotes' cuisine are cleaning up on the farmers' grain.

Weddle (89) observed that snow machines, or other motorized vehicles, can cause problems with wildlife populations through disturbance of the habitat. Migration or other habits can be changed; animals may disperse into poor food areas; and, if harassed, they become easier prey for those species which feed upon them.

Bollinger, et al, (10) studied the effects of snowmobile noise on wildlife in northern Wisconsin. The deer were normally subjected to peak sound levels between 45 and 65 dB(A) during test runs, rarely reaching levels of 75 dB(A). They reported that there seems to be little basis for concluding that changes in behavior and travel patterns were due to snowmobile noise alone. Their results suggest that snowmobiles have to be within sight of the deer before the animals react by moving away. Winter conditions were mild and the deer were in good physical condition, suggesting the possibility that a severe winter could produce different results. Also, a wood pulping operation was in progress supplying a constant source of food--and competing noise.

Dorrance, Savage and Huff (21) studied the effects of snowmobile traffic on white tailed deer to determine their impacts on distribution, habitat utilization and physiological response. They concluded that light snowmobile traffic caused the displacement of deer from areas immediately adjacent to trails; thereafter, increased snowmobile traffic caused no additional response. Deer returned to areas along the trails within hours after snowmobiling ceased. Snowmobile traffic resulted in increased home range size, increased movement and displacement from areas along trails. Some deer were found to be particularly sensitive to intrusions by man and vehicles and changed their home range to entirely different locations. They suggested that these effects could cause changes in the energy budget that could be detrimental, especially during severe winters. Results also suggest that deer become habituated to snowmobile traffic in heavily used areas.

Baldwin and Stoddard (6) reported on observations made by Bureau of Land Management employees in Idaho. They observed that elk in the area surveyed attempted to maintain about a half mile buffer zone between themselves and the snowmachines. They were frightened and caused to

move as much by the noise as by the sight of the machines and man. The frightened animals headed for more adverse, timbered areas, apparently to conceal themselves. They returned to the lower open areas where food was more available, usually within a matter of hours or days. Deer displayed identical tendencies but did not move as fast or as far. They appeared to be content moving into aspen pockets or north-facing slopes where trees and brush were more abundant. Deer exhibited more tolerance to the snowmobiles than elk.

Effects on Soils: In a study of the effects of snowmobile use on soils, Wanek (86) reported that alterations in the insulative properties of snow were suspected to cause retardation of organic matter decomposition and humus formation. He stated the soil microbe data are too scanty to be conclusive. However, the data indicate that snow compaction may significantly reduce the population of soil bacteria. Soil fungi appear to be affected less but the actual number of active mycelia may be masked by spore germination during incubations.

Hogan (33) tested snow depth, water content of the snow, and speed of snowmelt and reported possible beneficial effects to soils from snowmobile use. Compaction on snowmobile trails was found to decrease snow depth, increase water content and delay the achievement of zero snow cover. Increases in snow water content was seen as beneficial in areas where evaporation of snow exceeds its infiltration and where persistence of snow cover would protect steep and unvegetated roads until after the maximum runoff had passed.

Nelson (77) reporting on research done by the Soil Conservation Service showed that, if water content in a snowmobile track increased one-tenth to two-tenths of an inch, the machine sank. Thus, if the track were 10 inches deep, there could be from one to two inches more water in the compacted area. The compacted area melts more slowly in the spring, helping to create a more useful, controllable runoff. One snowmobile track, or a dozen, might not cause much difference, but a systematic contouring of a critical watershed with snow machines offers the potential of actually "farming" the snow pack for valuable water supplies.

Gullying has been recorded in some published accounts and noted in personal interviews (3). Such runoff appears to be a localized problem of soil erosion immediately adjacent to the user area. Harnik (29) also reports that snowmobile tracks, which often turn to ice from the pressure, could cause erosion when the snow melts.

Wanek (86, 87) also reported that temperatures beneath snow compacted by snowmobiles are significantly colder than those under undisturbed snow cover. Colder soil temperatures retard soil microbe activity in the spring, but this is probably not biologically significant because these decay organisms rebound very quickly once the soil warms. The growth of early spring flowers is retarded, and reproductive success is reduced where snowmobiles travel. Many herbs with massive underground storage organs, alfalfa included, are winter killed in the modified environment under snowmobile tracks.

Noise: In two separate studies of the effects of snowmobile noise on human hearing, Bess (8) showed that sound pressure levels with snowmobiles at mid-throttle demonstrated potential danger for a significant portion of human listeners. He stated that drivers should not exceed eleven minutes of snowmobiling and recommended that both drivers and riders wear customized ear protectors.

In a second study, Bess (8) showed that snowmobile racers incur greater hearing damage than pleasure drivers. He showed that stock and racing machines, in particular, produce noise levels far in excess of safety standards. Alterations to standard exhaust systems for racing produced engine noise from some machines that exceeded the threshold of pain at two-thirds open throttle. Bess stated that both stock and racing snowmobiles are capable of producing deleterious effects on the hearing mechanism. Pleasure drivers, riders and even spectators have been shown to exhibit marked temporary changes in hearing when exposed to snowmobile noise. He found that all snowmobile racers had permanent hearing losses while spectators could suffer temporary hearing losses.

In a Minnesota study, Wanek (85) found that all snowmobiles tested emit higher decibel levels at 10-30 m.p.h. than is considered safe. He stated that all machines tested met the acceptable noise standard at 25 feet; however, this does not protect the driver adequately from ear damage.

Researchers at Memphis State University evaluated the effects of noise on animals (4). Although the effects of noise from off-road vehicles were not specifically studied, the report raised the possiblity that many noise-induced physiological and behavioral changes, demonstrated in laboratory animals, could also occur in wild animals.

The 1969 International Snowmobile Conference recommended a certified decibel rating of not more than 50 dB(A) at 50 feet for snowmobiles entering public lands (75). This recommendation later proved unrealistic. A year later, the Society of Automotive Engineers (SAE) recommended 82 dB(A) at 50 feet for snowmobiles (Boggs 77). Parenthetically, the SAE standard for passenger cars is 86 dB(A) at 50 feet.

In the 1971 Senate Hearing, Hoene (77) stated that the 82 decibel level can be achieved. He indicated that it was ludicrous to suggest that the snowmobile industry should aim toward a 55 or 65 decibel level. If snowmobiles are required to conform to noise levels under 80 decibels, it would require changes in the snowmobile itself. Also in the Senate Hearing, Jennings (77) suggested that it was a combination of economics and human nature that prevented manufacturers from producing quieter machines than are required by law. He said more efficient mufflers are more expensive. Therefore, manufacturers try to hit an exhaust-noise level that says performance loud enough to please the customer without making it so loud that it is likely to become wearisome or to attract too much attention from the law. He also stated that muffling per se, has no effect whatever on the power output of a two-stroke engine.

In a discussion of noise in relation to wildlife, Olsen (62) stated that the drop in deer harvested in Quebec from 12,400 in 1964 to 4,000 in 1969 was in part the fault of snowmobile noise. He said that we just don't know how badly wildlife needs the dead silence of winter--and we may never find

out. By the time studies are completed, the harm may already be done. He indicated that most animals will accommodate to the noise in one way or another, but not during the breeding season. This is particularly true of animals with high metabolic rates, like minks.

Work carried out by the National Research Council of Canada has demonstrated that snowmobiles can be made that generate no more than 75 dB(A) at 50 feet (60). More recent work by Cowl Industries in Canada has resulted in even lower levels (78).

The U.S. Forest Service (78) concluded that Occupational Safety and Health Act noise limitations are exceeded after about 3 hours of snowmobile operation. Snowmobile noise is detectable in a typical winter forest within a distance of about 1½ miles. Significant temporary threshold shift was observed in nearly all snowmobile operators after periods of use as short as a half hour and permanent damage will likely result from continued exposure. Snowmobiles are considerably noisier than economic or technical reasons justify. The study recommended that all snowmobiles used on Forest Service land be limited to 92 dB(A), machines sold after June, 1972, not exceed 82 dB(A). In addition, all Forest Service employees should be required to wear hearing protection during snowmobile operation in the course of their work.

Bess (9) found that recreational helmets do not provide sufficient protection from snowmobile noise. He stated that riders should be encouraged to wear some form of ear protection in addition to their helmets. In another study, Stahl and Bess (70) found that only 3.7 percent of the snowmobilers surveyed utilized any form of hearing protection. The respondents believed that the snowmobile helmet provided adequate protection from the noise, in fact 77 percent of the subjects interviewed indicated that they did not feel snowmobile noise was a threat to their hearing.

MOTORCYCLES, MINIBIKES AND TRAILBIKES

Effects on Vegetation: Using aerial photography to study cycle use in the Panoche Hills of California, Miller (54) documented the increasingly broader paths being cut through the hillside vegetation by cycles He stated that cycle use had resulted in up to 60 percent loss of vegetation in a 1200 acre intensively used area. Photos of several hills in Redrock Canyon showed that both perennial shrubs and understory annuals were killed by cycle hill-climbing activities. On Forest Service lands where cycle trails cross streams, the banks were progressively broken down. The effects of these activities were demonstrated as reduced water quality and destruction of the protective stream bank vegetation. In the higher and wetter meadows, vehicle tracks disrupted the distribution of standing water and altered century-old patterns of vegetation.

In reporting on two-wheeled ORRV use in California, Baldwin (5) concluded that on hill climb areas where concentrated use continued over a period of five years, the adverse effects were more noticeable than on cross county courses. Soils were severely compacted, often inhibiting seed germination and revegetation.

A Bureau of Land Management study in California also reports that one-time-only use of the desert for cross country trail rides caused the least effects on vegetation (72). The most apparent vegetation losses were observed in or adjacent to parking areas, camping areas starting points, and overlooks often resulting in 100 percent denudation. When Creosote bush, present on approximately 78 percent of the desert, is destroyed, however, its effectiveness as a dominant wind and water control device is precluded for at least 10 years. A projection of future trends on increased use suggest that even the minimum amount of existing damage to the soil and vegetation on a single cross country trail in the creosote vegetative type could become very serious.

Watkins (88) cited the BLM study which reported 58 percent destruction of woody vegetation at a vehicle gathering point. He added: "If anyone questions the motorcycle's impact upon the land, the doubt can be erased by a look at any one of the hundreds of hillclimbing areas in California. Vegetation has been annihilated by the criss-cross patterns of riding paths that lace almost every square yard."

Hope (39) also stated that trail-bikers had stripped away 60 percent of the vegetation in repeated hill-climibing expeditions in California's Panoche Hills, a 1,200 acre area administered by the Bureau of Land Management. Murchie (59) further reported that motorcycle and trail bike use on the desert had crushed or removed rare desert shrubs, trees and cacti.

In an early article on trail bikes, Eissler (25) reported that many devastating forest fires are known to have been started by motorized vehicles. Along grass-covered or brushy trail areas, cycles have created an especially dangerous fire hazard.

Effects on Wildlife: Discussing the impacts of trail bikes on wildlife in the Panoche Hills study, Miller (54) stated the loss of vegetation obviously reduces the land's utility for forage and cover. This area is also considered to be prime habitat for chukar partridge, quail, doves and cottontail rabbits. Serious conflicts were noted because the peak use period of cyclists coincides with the nesting season. In forest land and meadows, deer and elk are affected by noise, fumes, startling speed and the destruction of vegetation, thereby detracting from the value of these areas as wildlife habitat. Miller also observed that openings in chaparral areas offered more favorable game habitat than vegetation. Thus the areas of greatest vehicle use and impact coincide with the areas most favored by wildlife.

Although lacking detailed information, BLM (72) reported in the California Desert study that motorcycle use occurred during the nesting period of most birds, causing nest desertion. Increased use of remote areas inhabited by bighorn sheep may contribute to their decline in numbers as they are forced into unsuitable environments. The report also mentioned that ranchers complained that weight losses occur when livestock is frightened or harassed by motorcycle users.

On the positive side, Deinema (77) testified at the Senate Hearing that motorized equipment facilitates hunter access to remote areas where game and fish might otherwise be underharvested.

In describing the impacts of motorcycles on fish, Hope (39) reported that loose mountain soils, powdered by ORV tires, washed downhill into nearby waterways, damaging the spawning grounds of golden trout. This area, in the Sequoia National Forest was closed to further ORV use. Watkins (88) also stated that indiscriminate motorcycle riding and other off-highway vehicles have adverse effects on wildlife, especially bighorn sheep, nesting birds, and on young broods of wildlife.

Effects on Soils: Miller (54) reported an estimated soil loss of 48 cubic yards per acre in a heavily used 3.5 acre hill-climbing area in the Panoche Hills. One photo taken in the Redrock Canyon area showed a three-inch deep rut caused by one motorcycle. Miller explained that the protective "desert pavement" had been broken and fine soil particles were churned up to be carried off by the wind or water. The study also noted that erosion was caused by motorcycles throughout the Cleveland National Forest and was considered most serious in mountain meadow areas. In chaparral areas, the loss of vegetation from vehicle impact resulted in accelerated soil erosion.

The Interior Task Force study also mentioned that motorcycle use had caused great erosion problems in the deep unstable soils on the Mark Twain National Forest in Missouri until a system of trails was worked out (80).

In an account of a cross-country motorcycle race on the California desert, Watkins (88) said: "The wind will clean the air of dust in an hour or so but nothing can be done to repair the earth." The problem is hundreds of thousands of grooves cut in the land, together with ruined watersheds. In altering the ecology of a hillside, he explained, a groove in a hill softened by rain, becomes a stream during the next rain, a little creek the next, and then a torrent until the hill is "crippled" and much of the ground cover is gone and tree roots are exposed.

Behme (7) reported that 1750 vehicles were counted in one month in the Panoche Hills and a closure was necessary because of damage. BLM managers had indicated that the trails could be used again when the hills were reseeded and vehicle concentrations controlled.

Murchie (59) reported losses to the study of geology and archeology due to the presence of ORV's on the desert. He noted the raiding of centuries-old petroglyphs and the breaking up of proposed archeological sites. Fialka (27) also told of the destruction of Indian burial mounds during a cross-country motorcycle race on the California desert. He complained that trailbikers, riding illegally on the Appalachian Trail, had created ruts and removed water bars placed across the trail to prevent erosion. This has resulted in severe damage to some parts of the trail.

McGuire (51) reported that trail bikes vary in their effects on a trail or the forest floor. The Forest Service found that motorcycles with small diameter wheels and narrow tires did the greatest damage.

Noise: Miller (54) called noise from motorcycles a major problem. He stated that the irony in this situation is that people leave the Los Angeles area to seek peace and quiet in a campground only to find that noise levels may be as high or higher than the city environment they left.

McGregor (50) studied the motorcycle noise problem at a proposed tract in the Cherry Creek Reservoir Park near Denver. Noise measurements were taken at existing motorcycle courses and in residential areas adjacent to the proposed site. He concluded that noise from a motorcycle is about 31 dB less at one-eighth of a mile from the track. To satisfy state noise regulations, a maximum noise level of 57 dB(A) would be produced by motorcycles one-eighth mile away and visible. An additional 10 dB reduction could be expected for motorcycles that are out of sight behind a hill, resulting in a level of 47 dB(A) on screened sites one-eighth mile from the track.

The National Industrial Pollution Control Council recommended that by 1973 noise levels measured at 50 feet from the source should be 110 dB for smaller motorcycles and 90 dB for larger motorcycles (80). By 1978 noise levels should be reduced to 83 dB for all motorcycles. The Council noted, however, that these standards might not be sufficient because of lower levels being set by state and local ordinances. The City of Chicago, for example, has set the permissable noise level for any motorized vehicle at 82 dB by 1973, and 73 dB for 1975.

At the 1971 EPA Hearing on noise level standards for motorcycles, Harrison (30) recommended a Federal standard of no more than 75 dB(A) effective in 1975 that would be based on a uniform method of motorcycle noise measurement. Also at the EPA Hearing, Nielsen (82) said that trail bikes and snowmobiles seem to be designed to produce as much noise as possible, perhaps enhancing the driver's experience, but destroying one of the most important values sought by traditional visitors to the wild country, and that is silence.

Eissler (24) called the trail-bike one of the most raucous intrusions in the back country. McGuire (51) said noise will no more prevent these vehicles from replacing horses in many forest roles than noise prevented automobiles from doing exactly that in cities. The best we can hope for is a good muffler design.

Milles (55) appealed for control of noise by the riders and race organizers themselves by stating that anyone running loud mufflers or expansion chambers should be disqualified and barred from further enduro competition. Youngblood (97) announced that the American Motorcycle Association will no longer allow unmuffled motorcycles to compete in competition governed by the AMA Rule Book and it will enforce a standard of 92 dB(A) at a distance of 50 feet.

Commenting on the two-stroke expansion chamber vehicles, Ditzel (19) said that the Industry is opening itself too much criticism by continuing to make these bikes. It's these bikes, about one percent of the Industry's total sales, that are causing most of the problem.

DUNE BUGGIES AND FOUR-WHEEL DRIVE VEHICLES

Effects on Vegetation: Miller (54) states that the environmental impacts of four-wheel drive vehicles are similar to those of two-wheeled vehicles except for cycle hill-climbing areas. Most problems arising from this type of vehicular use are the result of lack of restrictions on locations, particularly areas of concentration around campsites. He indicated the Forest Service has proposed areas be set aside for the exclusive use of motorized vehicles.

The California Desert study reported that vegetation is severely damaged in camping areas and assembly points on the desert (72, 73). Since most of the dunes support no vegetation, plant losses were not considered a major problem. However, localized sites often contain rare or aesthetically valuable plants which survive and propagate on the dunes. These plants are subject to extensive damage by motorized vehicles.

In the Back Bay National Wildlife Refuge, driving and walking on the dunes was reported to be responsible for killing present vegetation, thereby increasing the rate of dune erosion (77). Four-wheel drive vehicles were also blamed for increasing the potential fire hazard which makes woodland and rangeland owners apprehensive about opening their lands to recreational use (80).

Behme (7) stated that an area in the Panoche Hills had to be closed to vehicles when the native grasses wore thin and gullies deepened. He claims that the area could be reopened if the hills are reseeded and concentrations of vehicles controlled.

Hope (39) stated that dune buggies cause little ecological disturbance on flat, sandy beaches. When driven a few yards inland, however they disrupt the stability of seashore dunes by destroying their vegetative cover.

Referring to the Oregon coast, Chandler and Chandler (12) noted that dune buggy enthusiasts come to the best dune areas, put their machines into high gear, plunge from one ridge to another, tearing up sand, beach grass and struggling trees from their precarious root holds.

Effects on Wildlife: The Bureau of Sport Fisheries and Wildlife identified conflicts with bird life as one of the most serious problems with dune buggies (80). The increased number of people on the beach has completely eliminated nesting shorebirds, and has prevented sea turtles from using their ancient nesting areas. Migrating shorebirds cannot feed on the beach when vehicles are driving through at the rate of 200 per hour. Ghost crabs, once numbering in the millions on the beach, cannot be found now.

The California Desert study noted that camping next to water sources has created another conflict between wildlife and off-road vehicle use (72,73). Camping near water holes prevents their use by wildlife during critical periods. This problem is becoming more significant as this recreational use of the desert increases. Ranchers also complain that livestock is discouraged from drinking because water sources are often surrounded by campers.

Fialka (27) described the impact of dune buggies and four-wheel drive vehicles on the loggerhead turtles that once laid eggs along the beach at Back Bay National Wildlife Refuge. Officials believe the sand has become too compacted for the turtles to dig. Heavy traffic was also mentioned as a factor that prevented the turtles from laying eggs.

Effects on Soils: The California Desert study reports that, in general, the adverse effects on the soil from the use of dune buggies are negligible because desert dunes support no vegetation (72). However, on the Back Bay Refuge at Virginia Beach, the vegetation is a stabilizing force, planted specifically for that purpose at considerable expense to the Government (77). People driving and walking on the dunes have killed the vegetation growing there, thus increasing the erosion of these dunes.

Fialka (27) mentioned the BLM closure due to massive erosion in California caused by pick-up trucks and dune buggies. Another article blamed dune buggies for eroding some Atlantic beaches to the point that they are in danger of disappearing (1).

Watkins (88) stated that four-wheel drive vehicles are particularly menacing to the land because of their weight and power. He questioned that if a 180 pound trail bike can extensively damage a hill side, then what can a 2,800 pound, four-wheel drive Jeep do as it lumbers its way across some damp, sloping mountain meadow on its way to a previously inaccessible fishing spot? Watkins also said that the scars left on the desert by General Patton's maneuvers bore witness to the damage capabilities and the permanence of tracks left by four-wheel drive vehicles.

Noise: None of the literature reviewed specifically addressed the noise problems associated with the use of dune buggies and four-wheel drive vehicles.

ALL-TERRAIN VEHICLES, HOVERCRAFT, AMPHIBIOUS VEHICLES, SWAMP BUGGIES

Effects on Vegetation: Baldwin (5,6) reports that the destruction of vegetation on dry land and in marshes, with all the associated problems of erosion and sedimentation, can be severe wherever all-terrain vehicles are used. He added that advertisements for 6-wheeled ATV's which show them tearing through swamps and up and down hillsides speak for themselves. Lucas (42) also mentioned an objectionable ATV ad which said, "Even 2- to 3-inch trees topple--just drive right through the trees and brush."

Commenting on ATV's traveling through Florida swamps, the Interior Task Force reports that climatic conditions and vegetative types are more conducive to rapid regeneration and vehicle tracks are quickly obscured. This does not mean that long-range impacts may not occur (80).

Colby (14) stated that the width and multiple tires of ATV's could crush more vegetation than trail bikes, hikers, or horseback riders that have resulted in additional restrictions on their use. A 1970 Time article asserted without documentation that ATV's with their chubby wheels churning, have ravaged blueberry crops, chewed up stream bottoms and ripped the thin layer of vegetation of swamps (2).

Hope (39) reported that hunters using jeeps and ATV's in the Humboldt National Forest had caused an estimated $50,000 worth of damage to soil and vegetation.

Dunn (22) cautioned her readers to watch for second and third generation motorized recreation vehicles which will include amphicats, capable of swamp, lake and beach travel, and hovercraft, which can travel 45 mph on water, 60 mph on land and 75 mph on ice.

Effects on Wildlife: In discussing prohibitions on use of ATV's, Colby (14) mentioned that many states are becoming aware of the damage done to trails, vegetation and wildlife by careless use of these vehicles.

Elliott (26) described a moose-hunting expedition in northwest Ontario where ATV's lent access to an area of high concentration of moose. He counted 53 animals killed during the season from the lodge that served as headquarters for the expedition. He indicated that the 70 percent success ratio would not have been attained without the use of ATV's.

Effects on Soils: Lucas (49) referred to ATV ads which show wet meadows being ri ped up, mud flying from wheels churning up trails, and slopes so steep they frighteningly being mastered--and eroded.

Baldwin (6, 7) reported that in Connecticut both ATV's and trail bikes were causing erosion damage, as well as, alarm to people and horses. This required restricting these vehicles to trails of their own.

The Task Force reported that several years ago tracked vehicles were used for fire suppression activites in Alaska (80). In addition to damaging the fragile tundra vegetation, they apparently compacted ice crystals in the soil and increased the absorption of solar radiation. As a consequence, sublayers were subjected to increased melting and erosion, resulting in deep trenches.

In addition to the Time article (2) mentioned under effects on vegetation, U.S. News and World Report (1) states that wilderness areas such as Florida Everglades and the Big Cypress Swamp may be permanently scarred by airboat and vehicle trails.

Noise: In commenting on noise from ATV's, Baldwin (5, 6) said that these machines raise the decibel level of the surroundings to something approaching an artillery testing ground, and have already reduced many formerly serene vacation areas to wastelands. Several seasons under the gun of ATV's will make these gadgets as socially acceptable as the switchblade.

The National Industrial Pollution Control Council (82) calls for the reduction of noise from all-terrain vehicles, from a 1970 level of 85 dB(A) measured 50 feet from the source, to 70 dB(A) 50 feet from the source in 1983.

The Interior Task Force mentioned noise as one of the factors inhibiting sales of hovercraft for recreational use (80). Other articles pointed out

that noise was generally a problem with all off-road vehicles, leading to conflicts with other recreational users. Noise from ATV's is also likely to have adverse effects on wildlife.

Harrison (30) recommended that governmental bodies should establish the upper limits on the noise that can legally be emitted from an ORV and prevent the operation of vehicles which exceed this limit on lands under their jurisdiction. He proposed a limit of 82 dB(A) at 50 feet now (1973), 78 dB(A) in 1975, and 73 dB(A) in 1980. He stated that ORV manufacturers should be required to make the vehicle operators aware of the potential danger they are subjecting themselves to and suggest using hearing protection.

USER CHARACTERISTICS AND PREFERENCES

SNOWMOBILES

User Characteristics: In 1970, a questionnaire was sent to 1,400 selected snowmobile owners in Ontario (17, 84). The study showed that ownership registration was principally with male owners (97.5%), most of whom were married (87.5%). The average age of respondents was 38 years, and those with a family averaged two children. The occupational structure was similar to the overall pattern in Ontario, with 11 percent of the owners in the managerial group, 9 percent in the professional group and 7 percent in the sales group. Average family income of respondents ($10,874) was higher than that of the average Ontario household. One-half of the respondents (51.2%) lived in urban areas, indicating a much higher incidence of snowmobile ownership among rural residents who comprise 20 percent of Ontario's population.

The profile of a Michigan snowmobiler, as indicated in a 1970 study, shows him to be a male of 35 to 44 years of age. He is married and has two children (18, 23, 91). His income ranges from $5,000 to $15,000 with a median income figure of $10,000 to $12,000. Although snowmobile owners may vary from the highest professional level to students, thirty-two percent are craft union members which indicates a large middle income group enjoys snowmobiling. The study also shows that snowmobiling is a family activity.

A New York study contrasted differences in snowmobilers from Onondaga, an urban county, with those from rural Cortland County (96). Differences between snowmobilers in the two counties were significant but differences between the three residency categories (urban, rural and village) were highly significant. As is participation in most recreation activities, referring to all snowmobilers as a generic group may not be particularly useful. The study showed that rural residents, in comparison to their village or urban counterparts, were more likely to use a snowmobile for work, doing a higher proportion of their snowmobiling at night, and snowmobiling close to home. The study also found widely disproportionate levels of snowmobilers having incomes of $10,000 or more and less than $6,000, than was true among the general population of the two counties.

Lanier and Chubb (46) designed a snowmobile study to obtain data on a county by county basis. However, the total sample was reduced to 5,000 respondents, stratified into three regions in the state. The study found that mean income of snowmobilers in the state was $13,500, mean education was 12.1 years, mean age was 42.7 years, and mean number of children was 1.8. The occupational distribution was skilled workers--25%, semi-skilled--22%, self-employed--17%, and professional--11%. The study also showed that snowmobilers in the most urbanized region had the lowest mean age and the highest mean income. In contrast, the most rural region had the highest mean age and the lowest mean income.

In 1973, Snowsports Publications Incorporated conducted a study in which 5,000 questionnaires were mailed to snowmobile owners throughout North America (69, 34). The study found the average respondents age to

be 38 years. 86 percent were married, there were an average of 4.2 persons per household, 70 percent of the households had a total annual income of over $10,000, and 65 percent are non-urban dwellers (live in a town of 25,000 or less). The occupational distribution was found to be: craftsman/foreman--21%, managers/proprietors--15%, operatives--15%, professional/techical--11%, and farmers/farm managers--11%.

In a study of recreational use conflicts, Knopp and Tyger (44) reported pronounced differences in the level of formal education between snowmobilers and ski-tourers in Minnesota. Snowmobilers were more likely to have a high school education and some college level schooling than the state population; yet they were far below the ski-touring group in proportion of college graduates. Snowmobilers tended to be over-represented in the $6,000 to $10,000 income bracket, while ski tourers were over-represented at the $10,000 to $16,000 plus levels. The ski tourers were said to more likely belong to that segment of the population which has already "arrived" while middle-income individuals, predominant among snowmobilers, were still striving to improve themselves financially. The study further showed that snowmobilers originate predominately from small towns and rural areas while ski tourers reside mainly in large urban and suburban areas.

The Department of Interior Task Force (80) reports that the snowmobile has been quite adequately described as a vehicle emphasising the use for family recreation. Research on the profile of snowmobilers has shown that the average owner is 42 years of age, married, has two children, and has 1.45 snowmobiles in the household. It was shown that he is probably either a craftsman, foreman, manager, or proprietor of a business, and has a median income of $10,500 annually.

Whittaker and Wentworth (94) report that the general age distribution of registered snowmobile owners appear to follow the distribution of Maine's population. About two-thirds of Maine's 18 years or older population were 18-44 years of age in 1970 as compared to two-thirds of the snowmobile owners were 16-45 years of age. A higher share of snowmobile owners (47%) had incomes greater than $10,000 than the general population (29%) while 41 percent of the snowmobile owners had incomes of $5,000 to $9,999. Nearly three-fourths of the snowmobile owners had at least completed high school as compared to 44 percent of Maine's population.

Demographic characteristics were reported for North Dakota snowmobilers in a study completed in 1974 by Thompson (71). The average age of respondents was 37.9 years. Almost 81 percent were married, with an average of two children per family. The number of snowmobile drivers per family averaged 3.2 and 28 percent were members of a snowmobile club. Proportionally, there were more snowmobilers residing in urban areas than there were North Dakota citizens who reside in urban areas. The survey showed that respondents had completed, on the average, 12.4 years of education, and that family income groupings were: $15,000 and above--38%, $10,000 to $14,999--33%, and $5,000 to $9,999--25%. Occupations of snowmobile owners were, in order of greatest magnitude, farming, government workers and teachers, retail trade, business services, construction, and professional services.

Phillips and Pearson (66) collected socioeconomic characteristics of snowmobilers in Wyoming. They reported the median age of snowmobilers is the 41 to 50 years of age range, with more than 50 percent over 40 years of age. The educational attainment of snowmobilers was greater than that of the general Wyoming population. Education data showed that 38 percent were high school graduates, 26 percent had some college or were presently attending, and 13 percent were college graduates. Family income groupings showed that 33.6 percent of the respondents had incomes of $10,000 to $14,999, 31.6 percent made $6,000 to $9,999 and 23.9 percent reported incomes of $15,000 and over. In terms of place of residence, 34 percent were classed as rural farm and rural non-farm, 47 percent came from urban areas under 10,000 population and 19 percent from urban areas over 10,000 population. Occupational groupings showed 33 percent were in the manager/official/executive classification, 20 percent were professional/technical, and 16 percent were classed as farmer/rancher.

A comparative analysis between snowmobiling and cross-country skiing in Maine shows that 50 percent of the snowmobile users were in the 35 to 64 age range (53). In contrast, 64 percent of the cross-country skiers were in the 18 to 34 age range indicating that skiers are generally younger than snowmobilers. It appears that the majority of the cross-country skiers have professional or technical occupations (54%), with the second largest group being high school or college students (23%). The largest occupational group for snowmobiling was laborers (40%) followed by craftsmen/foremen (13%), professional/technical (12%), and managers/proprietors (10%). The study showed that 77 percent of the snowmobilers interviewed had a high school education or less. By comparison, 93 percent of the cross-country skiers had a college education or vocational training.

User Preferences: A study in Minnesota showed that 50 percent of the total use from Minneapolis-St. Paul occured in an area within 150 miles of the metropolitan center (45, 56). Responses showed that 70 percent preferred marked trails over unmarked trails. Of the snowmobilers surveyed, 75 percent preferred cross-country trails, although only 61 percent stated that they presently use this type of facility. The majority of cross-country trail users preferred a trail that returns via a different route (circle route). Only a quarter of the respondents felt they needed shelters and warming houses. About 28 percent of the respondents snowmobiled after dark. Approximately 80 percent would drive up to 50 miles for a one-day trip to snowmobile on cross-country trails. On weekend trips, 58 percent were willing to travel over 50 miles.

The Ontario study reported that 78.5 percent of the respondents indicated snowmobiling for pleasure was their main reason for purchasing a snow vehicle (17, 84). About 15.2 percent bought machines for hunting, ice fishing, transportation to ski areas, snowmobile racing, and other recreational activities. The average reported number of days of snowmobiling activity was 41.9. Snowmobilers averaged 3.7 hours per snowmobiling day for an estimated 155 hours during the season. Approximately 31 percent of the snowmobiling time occurred at night. It was found that snowmobile users preferred unorganized open lands, or bush and wooded areas in a hilly landscape with no special facilities except snowmobiling trails. Respondents showed very little interest in flatlands or in organized areas with prepared facilities. This lack of preference for organized areas with facilities was considered significant.

A study funded by the Upper Great Lakes Regional Commission found that 87 percent of the snowmobiling usage was for trail riding and pleasure (18,23,91). Hunting/fishing accounted for 8 percent while racing was given for only 2 percent of the activity. Of the group studied, 35 percent of the owners operated their machines on their own or a neighbor's property, 32 percent used state-owned land, and 18 percent used other private property. Many machines are used within five miles of home. Snowmobile owners who travel farther were seeking good trails, scenic expanses, their own recreational property away from home, and remote areas. One-third of the owners took one or more overnight trips. The median number of trips for this group was 4.0--for a total of 7.4 nights. The median distance driven by automobile on overnight trips was 277 miles, round trip.

Wilkins and Hill (96) reported in their central New York study that respondents averaged 51.8 hours on 14 January days, or 3.7 hours per day. Three-quarters of this use occurred on weekends and nearly one-half (46%) of all use occurred at night. Respondents strongly preferred interconnecting trails to permit more varied cross-country travel, together with good signing along trail routes. A large number (69%) desired trails conforming to the natural environment, avoiding a man-made appearance.

Lanier (46) reported that in Michigan most of the use occurred in the county of residence. In southern Michigan, below the snowbelt, respondents spent 40 percent of their time snowmobiling outside of their county of residence, whereas in the northern regions, more than 80 percent of the use was carried on within the county in which the owner lives. Most overnight trips were taken by people in the southern region (urban areas) and were between 100 and 300 miles from the owners home. Over half of the snowmobiling use occurred on the snowmobiler's own property or other private land with state land and public roads being the next most used. Public lands were more frequently used in northern regions because of greater availability. In the southern urbanized region, 54 percent of the time was spent trail riding and 32 percent in scrambling. In contrast, 70 percent of the use in the northern rural region was scrambling while trail riding constituted only 15 percent. The author concludes that patterns of snowmobile use are quite different in urban and nonurban regions.

In a study of 5,000 snowmobile owners throughout North America, Holecek (35, 69) reported that each snowmobile was used an average of 11.2 hours per week in an average season lasting fifteen and one-third weeks. The study also reported that four of ten (42%) took overnight snowmobiling trips and that 60 percent plan to take overnight trips during the upcoming season (1974).

The USDI Task Force report stated that the average snowmobiler spends 13 hours per week on his machine and one in every four operators belong to a club (80). He uses his machine primarily for trail riding, safaris, or group snowmobiling. In the Lake States it was found that one in three snowmobilers used public lands for his outings. The snowmobiler averages five overnight trips per season and sometimes stays several days in one place. He spends approximately $130 per stay. Two-thirds of the snowmobilers have attended an organized race and one-fifth have participated.

Brown and Hill (11) cited reasons for engaging in snowmobiling as follows: opportunity for adventure (24%) family winter fun (22%), enjoyment of nature (18%), a change of routine (16%), companionship (9%) and the thrill

or challenge of fast driving (4%). Over half of the respondents estimated they usually snowmobile more than ten miles from their departure point, while an additional 40 percent traveled 5 to 10 miles. Two-thirds of the respondents preferred interconnecting, naturally appearing trails through diverse types of countryside. About half of those sampled were concerned about trails being readily accessible and near their homes. The study also showed that 80 percent of all snowmobiling was done in the county of residence. Despite substantial public acreage available for snowmobiling, 53 percent of the respondents did most (80%) of their snowmobiling on non-public lands they neither own nor rent.

Whittaker and Wentworth (94) report that Maine owners used their snowmobiles almost exclusively for pleasure cruising. Throughout the 1970-71 season, 46 percent of the owners reported that they went snowmobiling two or three times each week (Monday through Friday). On weekends during this period, 33 percent averaged 5 to 8 hours of activity and an additional 23 percent averaged 9 to 12 hours. Over 80 percent reported that most snowmobiling occurred within 10 miles of home and less than 20 percent reported any activity beyond 50 miles of their homes. Nearly three-fourths of the owners preferred snowmobiling on unplowed woods roads. Other types of areas ranked as very desirable were: special trails (54%), open fields (49%), mountain trails (45%), and frozen lakes (42%).

Thompson (71) ranked snowmobile uses in order of time spent as follows: pleasures--30.9%, transportation--17.6%, work--14.9%, hunting and fishing--14.6%, emergency use--14.1%, and racing--7.9%. In an earlier study, Cox and Johnson (16) found that snowmobiles in North Dakota were used for recreation 78 percent of the time, feeding livestock--15%, transporation--5%, and rescue work--2%. Thompson also found that snowmobiles were operated an average of 19 hours per week with most activity on weekends. About three-fourths of the respondents indicated that less than half of their use took place after sunset. Nearly one-third of the respondents traveled out of state to snowmobile on an average of four times per year. The most frequented state was Minnesota, followed by Montana, Wyoming and Canada. Most snowmobiling was done on private property, highway rights-of-way, and lakes and rivers. Little use was made of state or federal parks. Large open-space areas were most often used, although trails in wooded areas were preferred. Owners suggested an average trail length of 18.4 miles with shelters or warming houses along the route.

In their Wyoming study, Phillips and Pearson (66) stated that snowmobiles were used for recreation 82.2 percent of the time. Approximately 72 percent of all snowmobile outings occurred in federal lands, the state's major recreation resource. Private lands accounted for about 27 percent of all snowmobile outings. Snowmobile use was mostly local in nature as only 34.7 percent of the respondents indicated that they participated in an outing that involved an overnight stay. Informally arranged group tours were most common in overnight trips usually involving only one or two family members. The most frequently used accommodations were motels or hotels (57%) and lodges or cabins (43%) while camping equipment accounted for less than one-half of one percent. Back country areas and activities overshadowed all other activities and possible locations. Types of activities preferred include: opportunity to see scenic areas (23%), cross-country touring (22%); snowmobile club and other group outings (17%); family outings (15%); hunting, trapping, or ice fishing (10%) and racing, climbing or testing machine capability (6%).

Results from the type of terrain preferred for snowmobiling included: forest and natural areas, mountains and back country (42%); forest roads and trails, other roads and trails closed to vehicular travel (29%); rolling pasture land, foothills, and moderately rough terrain (13%); and open fields meadows, and farm lands (8%).

OFF-ROAD RECREATION VEHICLES

User Characteristics: Available studies of user characteristics and preferences have generally included trail bikes, ATV's, dune buggies, four-wheeled-drive vehicles and other types of motorized equipment (except snowmobiles) into a single category of off-road recreation vehicles (ORRV).

One exception is a limited scope study of motorcycle riding in campgrounds conducted by Fillmore (28). He found that about 90 percent of the motorcycle riders in the campground were males. Age appeared the most important variable, because of its relation to licensing and use of public roads. Ages of respondents ranged from 11 to 58 years, with a median age of 35 years. Almost half of the respondents were under 20 and nearly one-third were under 16.

Peine (63) found in a study of ORRV's in Arizona that, for many ORV use was a family activity. The study showed that 45 percent of the respondents indicated their families were very involved in off-road vehicle activities and another 24 percent stated their families were moderately involved. Several families described to interviewers the fellowship and adventure they had experienced on vehicle outings.

For the most part, the ORRV user lives in a rural area (80). The urbanite and suburbanite participate to a much lesser extent, although this is expected to change in the future, Improved mobility, more free time and changing attitudes will contribute to the evolution of the ORRV user from essentially ruralist to urbanite/suburbanite. The task force also reported that individuals using four-wheel drive and ATV's do so for family recreation. The off-road use of motorcycles is also becoming more family oriented. To a lesser extent, dune buggies and swamp buggies still qualify for some family type use. Because of their relative newness as a recreation vehicle, use patterns have not yet been established for hovercraft. High initial cost and noise have inhibited the sale of this vehicle for strictly recreational use.

Johnson, et al. (42), reported that 69 percent of all respondents in an off-highway vehicle (OHV) study lived in the metropolitan areas of southern California. Most respondents indicated that there were either one or two operators in their households. About half of all operators were under the age of 16, although some variation in age makeup was noted within specific vehicle classes. Ninety percent of the respondents from minibike households reported at least one operator under 16. As the size of the vehicle increases, the number of youthful operators decreases to a low of 30 percent of the households favoring large motorcycles or dune buggies.

A study of ORRV's which included snowmobiles was conducted by the Indiana Department of Natural Resources (40). The study reported an age range of ORRV respondents of 15 to 66 years, with a mean age of 34 years. Males comprised

96 percent of the respondents and 80 percent of the owners were married. The mean grade of formal education was 13 with a range of 8 to 21 years of schooling. Family income of respondents was $9,000 to $14,999--42%, $15,000 and over--31%, and below $8,999--22%. Also noted in the study was the fact that family riding constituted 62 percent of the use, individual riding--30 percent and group riding--6 percent.

User Preferences: The ORRV study in Arizona reported that 68 percent of all respondents traveled mostly over jeep trails (63). Dry river beds and washes, the terrain most easily accessible to Tucson ORRV users, attracted 14 percent of the use. Cross-country areas with no trails and sand dunes accounted for about 7 percent of the use. The mean of off-road trips per month for all respondents was 2.05 trips. Vehicle oriented recreation users made more trips per month than either the land oriented users or the activity oriented users. Activity oriented trips made up 51 percent of all use, while land oriented and vehicle oriented trips accounted for 26 percent and 23 percent of the use, respectively. The most frequently mentioned single activities include: hunting (32%), see countryside (18%), challenging terrain (12%), work on vehicle (6%), exploring (7%), fishing (5%), and camping (5%).

The Indiana study reported that 93 percent of all ORRV's were purchased for pleasure or recreation riding as compared to 12 percent for transportation and 6 percent for competition (40). When asked what type topography they preferred the responses indicated that 57 percent preferred hilly, wooded areas; 43 percent preferred hilly, open land; and 29 percent preferred flat, open or wooded areas. Almost 80 percent of the respondents indicated an interest in trails. Responding to another question, 53 percent expressed interest in unorganized areas with no special facilities.

Johnson, et al. (42), reported that members of the average respondent household spent two weekends per month at a use area. The average operating time was just over five hours per day, although this varied with the vehicle class. The majority of respondents ranked state-owned lands highest, with federal lands, private property, city- or county-owned areas, and commercial parks listed next in descending order. Cycle owners and dune buggy operators ranked hilly terrain as their first preference and rolling land second, while minibike users preferred rolling land. Informal competition, hill climbing, camping, sightseeing, organized competition, and cross-country touring were the most popular activities associated with the operation of off-highway vehicles. More than 50 percent of users of larger motorcycles rated competitive events and hill climbing first. Hill climbing, sightseeing, camping, and cross-country touring were named with almost equal frequency by the operators of dune buggies.

USER CONFLICTS

The Interior Task Force on Off-Road Recreational Vehicles reports that one of the greatest controversies surrounding ORRV use is precipitated when an ORRV user ventures into the quiet and serene outdoor areas previously accessible only to the foot hiker, snowshoer, or backpacker; where presence of noise and sight is generally restricted to the wind sky, animals, and landscape (80). Equally disturbed is the cross-country skier who finds a snowmobile path in his way or the hiker who sees the tire or track marks in his trail.

Conflicts are inevitable between off-road vehicle proponents and more traditional outdoorsmen states Baldwin and Stoddard (6). Off-road vehicle operation can spoil the pleasures of hiking, but the reverse is rarely true. Trail bikes and motorcycles on Bureau of Land Management lands have caused dust and noise acceptable to other drivers but obnoxious to campers, hikers, hunters, and ranchers In the East, trail bikes are reported by one Virginia official to be very disturbing to hikers, campers, horseback riders, and picnickers. Yet left to their own devices, hikers, campers and other non-motorized users are virtually helpless against this intrusion. Thus, land that could otherwise support a variety of less obtrusive recreational uses can become off-road vehicle territory by default.

Executive Order 11644 established policies and procedures so that the use of off-road vehicles on public lands would be controlled and directed--to minimize conflicts amoung the various users of those lands (83). The Order directed that areas and trails shall be located to minimize conflicts between off-road vehicle use and other existing or proposed recreational uses of the same or neighboring public lands, and to ensure the compatibility of such uses with existing conditions in populated areas, taking into account noise and other factors.

Muntz, Deglow and Campbell (58) report that, because of their range, off-road vehicles completely upset the delicate balance between accessibility and back country that is based at present on a hiker's range and trail length. Contempory off-road vehicles when operating in the national forests use an overwhelmingly disproportionate share of a limited public resource. Ways should be found either to reduce this share or increase the size of the resource. To reduce the impact of vehicles in forested areas, we must reduce their speed, range and recognition area (at present, primarily noise). The impact reduction could be accomplished by a maximum speed reduction to say less than 5 mph (from about 30 mph now) and a noise reduction to give an audible recognition area equal to or less than the visual recognition area.

In their discussion of recreational carrying capacity, Lime and Stankey (47) comment that more visitors competing for the same amount of recreational space will frequently mean that they interfere with each other's activities. Snowmobiles, trail bikes and ATV's are largely incompatible with foot travel. Allowing high intensity bike use in the immediate vicinity of an important nesting area for eagles could create a serious conflict. Separating or zoning conflicting uses can assure the perpetuation of a range of recreational opportunities in an area and the user's right to a free choice among alternative forms of recreation. In winter, setting aside separate trails for snowmobilers and snowmobilers or cross-country skiers seems especially warranted if management wants to maximize enjoyment for both groups.

Knopp and Tyger (44) report that a recreation activity can become associated with a particular social grouping so that the conflict may become increasingly polarized. A well-recognized conflict is evident between those who utilize motorized vehicles and those who prefer self-propelled forms of recreation. Conflicts over the use of public land for recreation may be more than the result of a simple effort to gain or retain territory. Fundamental differences in attitudes toward the environment and public land management may exist between participants in different forms of outdoor recreation. The study revealed a consistent and significant difference in attitude between snowmobilers and ski tourers which may be indicative of larger cultural trends. Recreation activities often serve as a symbolic identification for a cultural group. Proponents of ORV's have been heard to call their opponents "long-haired unemployed hippies" and "elitist millionaires" while referring to themselves as "patriotic," "family people," or "hard-working middle-class citizens." The ORV users have often been stereotyped as "lower-class, uneducated and consumer oriented."

The Indiana Department of Natural Resources study (40) indicates that conflicts occur between ORV proponents and the more traditional recreationists on the Department's properties. Because of their speed, range and versatility, these vehicles can quickly dominate a large acreage, since competition of recreation uses is inherently unequal. Furthermore, ORV's can reduce the pleasure and enjoyment of other traditional recreators, while the opposite seldom occurs. The noise and physical presence of ORV's in quiet locations can be disruptive to persons who enjoy those recreation activities presently provided for on the Department's property. One of the primary uses of our wild areas should be for the rejuvenation of the human spirit and all citizens should have the right and opportunity to enjoy the peace and quiet as a visitor to Indiana's woodlands. The invasion of ORV's is incompatible with this basic human right and need. A majority of the Department's property managers and enforcement officers felt that ORV activities would be incompatible with the other activities now being enjoyed. They stated that hunters, fishermen, campers, hikers, canoers, swimmers, picnickers and horse riders would experience conflicts with ORV users. The report also indicated that ORV riders operate many different kinds of vehicles ranging in size from the smallest mini bikes and dune cycles to the largest 4WD's. It was found that various kinds of vehicles were often in direct conflict with each other. Trail bike riders stated that they did not like to ride on trails which were wide enough for dune buggies and 4WD's. The ATV's were found to be incompatible with the faster ORV's on land. Even the seasonal use separations for snowmobilers and ORV users were proving unsatisfactory because the periods of use were being extended for all types of vehicles It was concluded that you cannot mix different types of off-road vehicles in the same spot at the same time.

In a study of user preferences for outdoor recreation in the Rattlesnake watershed, Conklin (15) found that a majority of the users from nearby Missoula preferred non-motorized recreational activities. Of the watershed users interviewed, 35 percent engaged in hiking, 25 percent engaged in walking for pleasure, and 17 percent engaged in picnicking as compared to 13 percent that engaged in motorbike riding. The study also showed that motorbike riding was in-reasing sharply while other types of recreational activities were declining. He stated that the consequence of little or no planning for recreation in the Rattlesnake watershed was that some activities were in direct conflict with the enjoyment of others. In an analysis of motorcyclists versus hikers, the

users who visited the area because they enjoyed peace and quiet, were particularly annoyed by noisy motorbikes. He concluded that the greatest conflict has emerged between motorized users (motorcycles, automobiles, snowmobiles, etc.) and non-motorized users (hikers, walkers, snowshoers, horseback riders, etc.). Usually the resentment is one-sided with the non-motorized users finding the motorized users highly objectionable.

In a study of winter recreation conflicts on the same area, Mahoney (52) found that 90 percent of the non-motorized recreation users who encountered snowmobiles mentioned one or more specific objections. Eighty-five percent of the individuals interviewed mentioned solitude disturbance (noise and gas fumes) as their primary complaint against snowmobiles. He concluded that snowmobiling conflicts with non-motorized recreation mainly because of the noise of the snowmobiles. A variety of additional factors also contribute to the conflict, pointing to a clash of the norms of the non-motorized recreationists and snowmobilers. He states that there is no conflict among non-motorized recreationists unless the area is crowded. Snowmobilers had no objections to the presence of either non-motorized recreationists or other snowmobilers and they appear insensitive to crowding. Mahoney further reported that conflicts between snowmobiling and non-motorized recreation appear to be greatest near automobile access points and on trails. Because snowmobilers can travel much further than non-motorized recreationists in the same amount of time, it is difficult for the non-motorized recreation users to avoid meeting or hearing snowmobiles.

SUMMARY AND CONCLUSIONS

With this type of study, it is difficult to separate facts from opinions. Conclusions at this stage in the planning process should be considered preliminary and somewhat tenuous. With this note of caution, however, certain concluding remarks seem to merit consideration.

A proliferation of pro and con literature is available to the researcher, most of which was published during the period of rapidly expanding popularity of snowmobiles and off-road vehicles. Much of this literature was conceived as the result of a presumed crisis while opposing interests shouted insults and accusations across a no-mans-land of compacted snowfields. Instead of providing proof of impacts or pointing out serious use conflicts, most writings have proliferated the controversy, causing further polarization of interest groups.

Poor study design and topics mostly of academic interest have also complicated the process of analyzing those materials most relevant to the planning and managing of resource use and users. What value is it to the decision maker to know that the growth of soil bacteria is retarded because of lower soil temperatures caused by snowmobile compaction, when the population of bacteria quickly rebounds after short delays during spring warm-up periods. Also, how can a manager convince a user that the noise from his snowmobile has detrimental effects on wildlife from evidence collected in an area that wildlife has acclimated, in part, to the noise of chain saws. In some studies, one of the most profound concluding remarks is that more study is needed.

On a positive note, several studies provide insight for at least temporary solutions in Montana, although their findings may not be directly applicable to the problems and conditions of that state. First, few studies have been undertaken in the northern Rocky Mountain area. A long-term analysis, under way at the University of Idaho (68), has not progressed sufficiently far to provide assistance at this time. Future findings, however, should have applicability in Montana as well as Idaho. User studies in Wyoming and Utah (66) provide information that can be applied, preliminarily, in Montana until in depth studies can be completed in this state. These studies can also serve as a first approximation to assist in the design and consummation of in-state user studies to be undertaken in the future. Summaries of these studies are included in the text and will not be repeated here.

Some excellent user studies have been completed in other states, particularly in the midwest and the New England states. Although not directly applicable to Montana, the types of information generated should be valuable as design models for state studies. Socioeconomic characteristics, origin and destination, and user preferences, which a number of these studies contain, would be of value if similar data were obtained here. For example it is of little interest in Montana to know that 70 percent of the snowmobilers in Minnesota prefer signed trails and that demand for overnight camping is almost non-existent. It does, however, emphasize that this is the kind of information that should be obtained from Montana users. Likewise, it is important for the resource manager to know if the off-road vehicle users in his area are of local origin, from other areas of the state, or out-of-state tourists.

Except for isolated examples, long-term environmental deterioration resulting from off-road vehicle use has not been proven or disproven. The analysis of vegetation losses, in most of the case studies reviewed, delt with snowmobile damage in young pine plantations. Admittedly, serious losses can occur under certain conditions, particularly if snow cover is limited. In Montana, however, this type of damage does not appear to be a major problem as snowmobilers infrequently enter plantation areas. Damage to winter crops could be a serious problem where heavy use occurs in agricultural areas. It would appear that existing trespass laws and damage suits should continue as the major control on these private lands instead of a complex, possibly inoperable, system of public regulation.

Vegetation damage can present serious localized problems from summer use of trail bikes and four-wheel drive vehicles. Since vegetation losses, soil erosion and soil compaction are closely interrelated, they must be analyzed together in terms of off-road vehicle impact. Serious damage and erosion has resulted from hill climbing activities, at rallying points and on areas of intensive use, particularly where heavy use occurs on steep terrain and on shallow or highly erodable soils. At this time, there does not appear to be sufficient evidence to support closures because of snowmobile damage to soils except where use occurs on insufficient snow cover.

As with most environmental impacts, the effects of off-road vehicles on wildlife are highly complex and the results reported by various studies of these impacts are often inconclusive and sometimes contradictory. Summer use appears to have limited impacts because game animals are dispersed and able to move away from apparent danger with relative ease. The impacts of off-road vehicles during hunting season is closely related to increased access This problem is fairly well documented and necessary controls can be imposed where serious conflicts between vehicle use and wildlife become evident.

Snowmobile impacts on wildlife are much less understood, in spite of the fact that several studies have evaluated this problem. The concentration of big game animals on winter range offers the potential of serious impacts because of increased hunter and vehicle operator access. Physiological and psychological disturbances can be serious, if not fatal, during periods of severe winter stress. The impact of noise on wildlife has been evaluated also with divergent results. Although its effects cannot be discounted, it appears that man's invasion of wintering grounds, that were heretofore largely inaccessible, is causing the major conflict not just noise per se. Whether man invades winter game range by constructing highways and subdividions or by converting it to agriculture, the negative impacts on wildlife may be parallel to the temporary invasion by snowmobiles

Solutions to conflicts between off-road vehicle use and wildlife during winter months appear to be closely related to the larger problem of land use which can only be solved through broadly based land use planning and control. If game winter ranges are to remain intact and functional, they must be protected from subdivision and other incompatible land uses as well as from snowmobiling.

The extreme concern for environmental impacts has resulted in overlooking many of the problems related to user conflicts. Off-road vehicle use has caused intense competition between diverse recreation user groups that land

managers have been unable or unwilling to, in many cases, recognize, let alone deal with effectively. The response has largely been "don't do this" or "stay out of that area" rather than exploring the wide array of more subtle controls for reducing user conflict. Legislative controls such as noise limitations have made considerable strides toward reducing one of the more obvious (or most frequently mentioned) sources of complaints from non-motorized users. Controls on noise have also benefited wildlife and rural residents, as well as, other recreation users.

There is little evidence in the literature reviewed of serious study of more deep seated conflicts arising from psychological and sociological differences between competing recreation user groups. We do not know how off-road vehicle use effects the non-motorized user other than it appears to significantly reduce the benefits derived from a recreation experience. Some studies have at least taken the initial steps in analyzing these impacts by determining user characteristics and preferences. User profiles obtained from some of these studies have demonstrated that differences in sociological groupings do exist. They should be accounted for in recreation planning and management if satisfactory opportunities are to be provided for all user groups.

Some of the literature suggests using various types of controls to reduce user conflict. No systematic efforts to identify or test the effectiveness of a wide variety of possible controls were evident, especially the more subtle constraints. Some of the suggested tools for reducing conflict include information and education, spatial and temporal zoning, separation of incompatible uses (use management), trail developments (design), regulations and enforcement, and voluntary compliance with restrictions. To effectively use and evaluate many of these controls, it is vital to obtain additional information on various user groups and their reaction to these and other constraints on off-road vehicle use.

RECOMMENDATIONS

A major element of this report is its recommendations for future studies that should be initiated by the Department of Fish and Game. Also, preliminary management policies and techniques for the regulation of snowmobile and off-road vehicle use are suggested. For continuity, it is imperative that relevant agency programs continue or that they be expanded prior to the completion of more detailed studies. At the risk of some redundancy, recommendations have been grouped into the following categories: (1) environmental impact suties, (2) user studies, (3) resources and opportunities, and (4) policies and regulations.

ENVIRONMENTAL IMPACT STUDIES

The complexity and cost of environmental analyses would tend to discourage large scale studies of this type at this time. Since many of the same factors are analyzed in land use plans, it is recommended that the environmental impacts of snowmobiles and off-road vehicles be included as an element of all state and county land use plans. With this approach, fragile soils, steep and unstable topography, high-hazard fire areas, winter game range, wildlife nesting and breeding areas, and other areas of probable environmental degradation can be identified. In addition, the controls applicable to the implementation of land use plans may closely parallel those needed to regulate and channel off-road vehicle use.

This recommended delay in initiating detailed environmental impact analyses should not be interpreted to mean that a l efforts in this field should be postponed. Instead existing and readily available information should be compiled, analyzed and interpreted to guide near future (3 to 5 years) policies and programs of the Department. A largely untapped source of planning information is the large force of field personnel within the various federal, state and local agencies.

It is therefore recommended that a survey of field managers, enforcement personnel, extension specialists, and other knowledgeable individuals be initiated to record their field experiences related to the environmental impacts of off-road vehicles. Field personnel should be asked to document and map locations of wildlife winter range, soil erosion problem areas, areas of conflicts with wildlife and other recreation users, areas of vegetation damage, and other environmental problem areas. Data from this initial survey should then be compiled and analyzed to provide the basis for preliminary management policies. In addition to the suggested survey, universities and other publicly supported research groups should be encouraged to continue the investigation of special problems concerning the environmental impacts of snowmobiles and off-road vehicle use. The Department should be fully appraised of these research efforts so their findings can be more effectively utilized in planning and management.

USER STUDIES

In my opinion, highest priority should be placed on the collection of user information. Rather than undue preoccupation with the ultimate in statistical reliability, user surveys should be designed to obtain as broadly based information as possible. Instead of a one stage user interview process, it is recommended that several studies, or possibly a multi-stage survey, be conducted. The survey should include: (1) a survey of registered snowmobile owners, (2) an on-site survey of users while engaged in the activities, (3) a household survey of motorized and non-motorized users, and (4) an origin and destination study of off-road vehicle users in route. The various stages of the survey should obtain information from each of the state recreation planning districts. In addition, the survey questionnaires should all contain certain questions on user group composition to permit interlocking, cross-survey analyses.

The first stage should be initiated immediately to take advantage of the coming snowmobiling season. A mail-out questionnaire to a selected sample of the registered snowmobile owners should be designed to obtain data on user characteristics and user preferences in sufficient detail to construct a user profile and patterns of use in each planning district.

The second stage could use a personal interview technique where trained interviewers would obtain information at trail heads or on trails while respondents are engaged in the activity. A less costly alternative technique would be a system of self-registering stations at trail heads similar to those used at entrances to wilderness areas. The self-registering technique would require a follow-up questionnaire mailed to a selected sample of the respondents. The purpose of this survey is to collect on-site use patterns, types of areas and facilities preferred, and point of user origin for specific trails or areas. Data should also be collected from the non-motorized recreation users in the same area to show conflicts between user groups. Stage two should also be conducted during the coming winter season.

The third stage should use either the mail-out questionnaire or a telephone interview process. Rather than a separate off-road vehicle survey, data on motorized user participation, socioeconomic characteristics, preferences and possible conflicts with other activities would be collected as part of the next state-wide recreation demand survey. This approach will tend to reduce some of the bias of a special off-road vehicle demand study, it will keep motorized use in prospective with other activities, and it will eliminate a costly redundant study.

Stage four should also take advantage of other survey efforts, if possible. The best approach would be to piggy-back the origin and destination study on screen line surveys conducted by the State Highway Department. Studies that determine traffic volumes might also be designed to collect data on ORV out-of-state visitor use, origin and destination data on motorized vehicle users, and the number of users traveling from one planning region to another. An alternative to interviewing ORV users in route would be a hand-out, mail-back questionnaire given to respondents at highway check stations or at visitor information booths.

RESOURCES AND OPPORTUNITIES

The Department of Fish and Game should take the lead in the establishment of a system of off-road vehicles. Where feasible trails may extend onto federal and private lands and the lands administered by other state agencies. Design specifications to guide developments should be modeled after those developed in other states through experience. They should emphasize safety, low development and maintenance costs, limited environmental impact and minimum conflict with other recreation user groups (37,38).

Basic facilities such as plowed parking lots, pit toilets, and trail signing should be provided. The standard snowmobile sign system, used by most federal and state agencies, should be adopted for use in marking trails (36,37). Trail developments should where possible, take advantage of existing roads (i.e., logging roads), abandoned railroad grades, power line rights-of-way, and service facilitieis in parks or roadside rests. In most cases, construction should be limited to tieing existing trail segments together into a system or to improving traffic flow patterns.

An inventory of existing and potential trail opportunities should be undertaken in the near future. Again, the planners should rely heavily on field personnel to identify and record trail inventory data. The mapping and analysis phase should emphasize the development of a system of trails oriented to the preferences of user groups that frequent the county or planning district under consideration. Also, the mapping process should include the preparation of trail guides and informational brochures for public distribution and use.

POLICIES AND REGULATION

One fact stands out in the literature; the use of off-road vehicles is increasing rapidly and it should be recognized as a legitimate use of public lands. This does not mean, however, that ORV use should be allowed without adequate regulation as to the amount, time and location of this use. It also follows that proper control must be based on a broadened information foundation so planning and administrative processes can serve clientele groups effectively. To accomplish the recommendations previously made, a well thought out planning program should be developed to guide the overall effort. The ORV planning program should be an element of the more comprehensive land use planning program and the outdoor recreation planning program and it must be closely coordinated with the budget process.

An effective enforcement program should be designed to encompass state, federal and local enforcement personnel. Uniform enforcement procedures and techniques should be encouraged by the county sheriff's office, state conservation officers and federal enforcement personnel. Obtaining uniformity would require the development of enforcement guidelines, training sessions and cooperative agreements between agencies. Examples would be the enforcement of game laws and trespass laws which should have the same vigorous enforcement as the regulation of hunting now enjoys.

Spatial and temporal zoning should be used as a primary tool for restricting use in areas of high environmental impact or in areas where motorized use conflicts with other recreation users. This technique, now used effectively in federal wilderness areas, has application to areas of unsuitable soil and topography, game wintering areas, nesting and breeding areas, and wildlife preserves. The use zoning concept, similar to that applied to wildlife preserves could emerge as a major element of an ORV management program. Activity zoning could also be applied to state parks and other heavily used recreation areas (i.e., Rattlesnake Creek watershed near Missoula, Hyalite Creek watershed near Bozeman, and Jewel Basin near Kalispell) where conflicts with other recreation uses are evident. Rather than being applied as a rote process, use zoning should be modified to fit local conditions and requirements.

It is recommended that uniformity in the regulation and management of off-road vehicles be pursued with vigor. Motorized users can, and often do, travel from state lands to private lands, to federal lands on a single excursion. Parochial agency management and regulation breaks down into a nightmare of confusing rules, many of which are unenforcable. Cooperative management agreements and trail developments, uniform regulation and enforcement, and standardized signing are examples where working together can benefit both the user group and the administration of the program. The Department of Fish and Game should take the lead by enlisting the cooperation of other public agencies and representatives of both motorized and non-motorized user groups.

Finally, I recommend a review and updating of existing state legislation designed to regulate off-road vehicle use. Revisions should reflect the experience of other states and the information derived from the studies summarized here in earlier chapters. Legislation, as well as administration, should be responsive to the studies recommended in this report.

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